Tube Box

that authentic valve sound — using diodes

Design by M. Radler

The Tube Box lends to a solid state amplifier that characteristic valve sound required by any self-respecting guitarist.

Guitar valve (or 'tube') amplifiers, as used on stage or in the studio, derive their characteristic sound from the clipping behaviour of the valves when overdriven. Whereas the effect of clipping in a solid state amplifier is very unpleasant (and for many this alone is reason enough not to touch them), it is common to drive valve amplifiers into clipping. But with a disadvantage: if a valve amplifier is to be overdriven, the volume control must be turned all the way up. This does not always go down well with the other band members (or with the neighbours!). With the Tube Box circuit described here, which sits between the guitar and the valve amplifier, this is not necessary. The tiny unit applies the desired distortion to the input signal of the amplifier. The controls on the Tube Box are two potentiometers and two switches, which allow the user to choose from a wide range of possible settings, making the unit suitable for the whole spectrum of guitar music from smooth, warm blues to screaming heavy metal.

Before and after the diodes

The heart of the circuit, the distorter itself, is built around IC2.A. Two pairs of diodes, connected in anti-parallel, are responsible for creating the distortion. D1 to D4 clip the signal gently in a similar way to valve amplifiers, not suddenly as in solid state amplifiers. When the signal amplitude becomes very high, LEDs D5 and D6 also come into play and

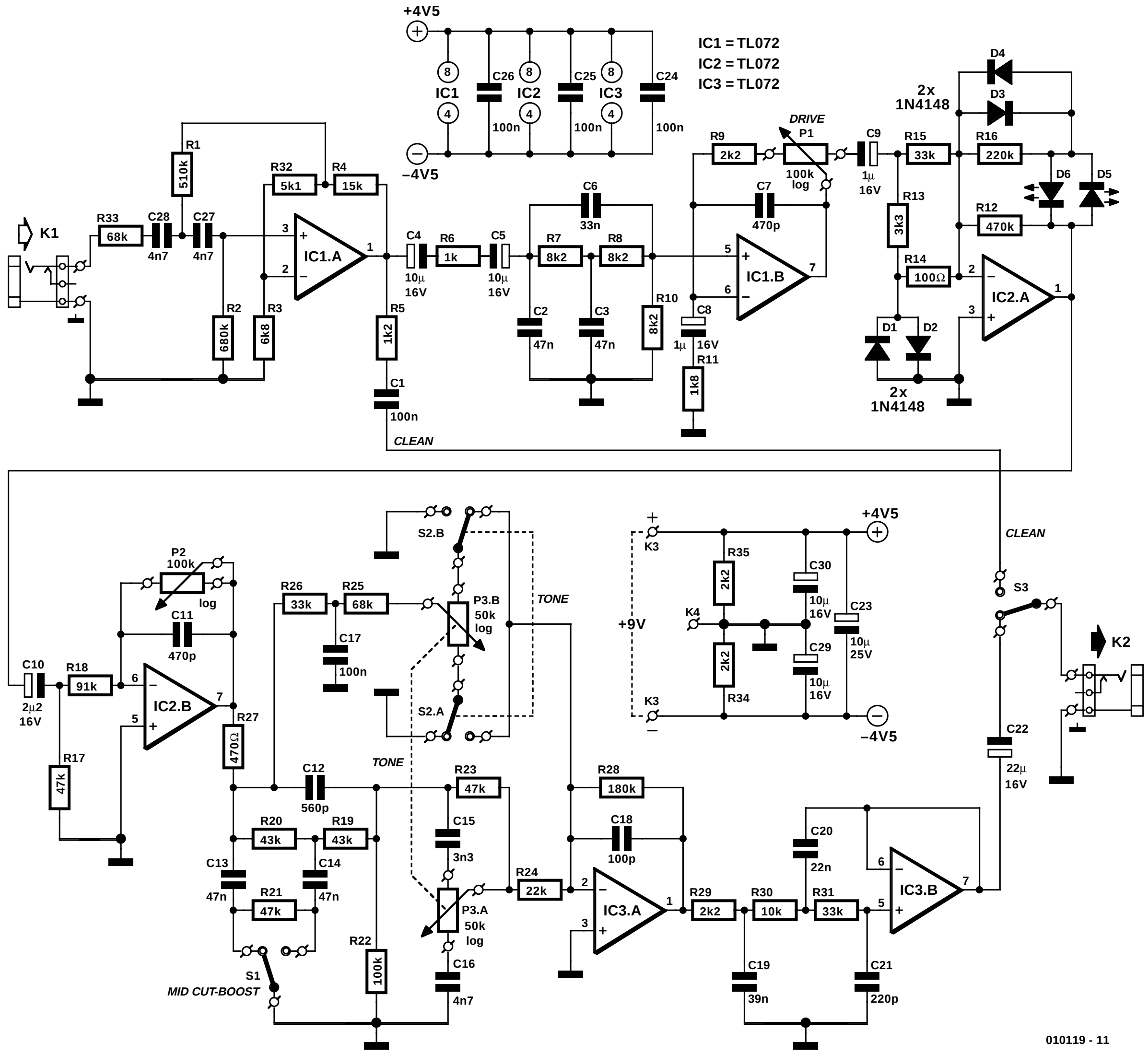


Figure 1. Several filters and a distortion stage: the Tube Box circuit.

reduce the gain of the op-amp. The combination of these two distortions simulates fairly accurately the distortion typically introduced by valves, since the clipping diode adds odd (and therefore pleasant-sounding) harmonics to the notes.

We now come to the circuitry before and after the distortion stage. In order for the distortion stage to work as 'naturally' as possible, the input signal must be suitably preprocessed. The signal from the guitar is first taken through a high-impedance input circuit that forms a filter, and then to operational amplifier IC1.A. The op-amp functions as a buffer-amplifier and prevents too high a load being presented to the high-impedance guitar pickup.

From the output the signal goes two ways: first, via a filter to footswitch S3, and second, via a filter to IC1.B. This op-amp amplifies the signal by a factor of about 5. The footswitch allows the distortion circuit to be bypassed, taking the guitar's signal practically unchanged to the output socket.

On the way to the distortion stage the signal goes via a band-pass filter, and then to another buffer-amplifier. The band-pass filter has the effect of boosting the important part of the frequency spectrum. The gain is adjustable via potentiometer P1. Note that this affects not the volume, but rather the degree of distortion. The further the potentiometer is advanced, so the more distortion is applied to the signal before it arrives at IC2.B. Here, we have a further potentiometer with which the volume can be adjusted so as to make the signal level at the output the same whether it goes through the whole circuit or whether it bypasses the circuit via S3. This ensures that there are no sudden jumps in volume when the guitarist switches between the distorted and the clean sound. Of course, P2 can also be adjusted to make the distorted signal louder than the undistorted, so that the guitarist's sound comes more into the foreground during a solo, for example.

There follows a fairly sophisticated tone control circuit with a range of possible functions. Switch S1 allows the user to choose between boosting and attenuating the middle-frequency range. Attenuation is especially suitable for 'harder' music, such as metal, while for the 'softer' blues solos the middle-frequency range should be boosted.

The tone adjustment is unusually constructed, but is nevertheless effective. Double-gang potentiometer P3 simultaneously adjusts the treble and bass, while the position of S2 determines whether the bands are adjusted in the same or in opposite directions. Thus in one position the treble and bass are either boosted or attenuated together, while in the other position the bass is attenuated while the treble is boosted, and vice versa.

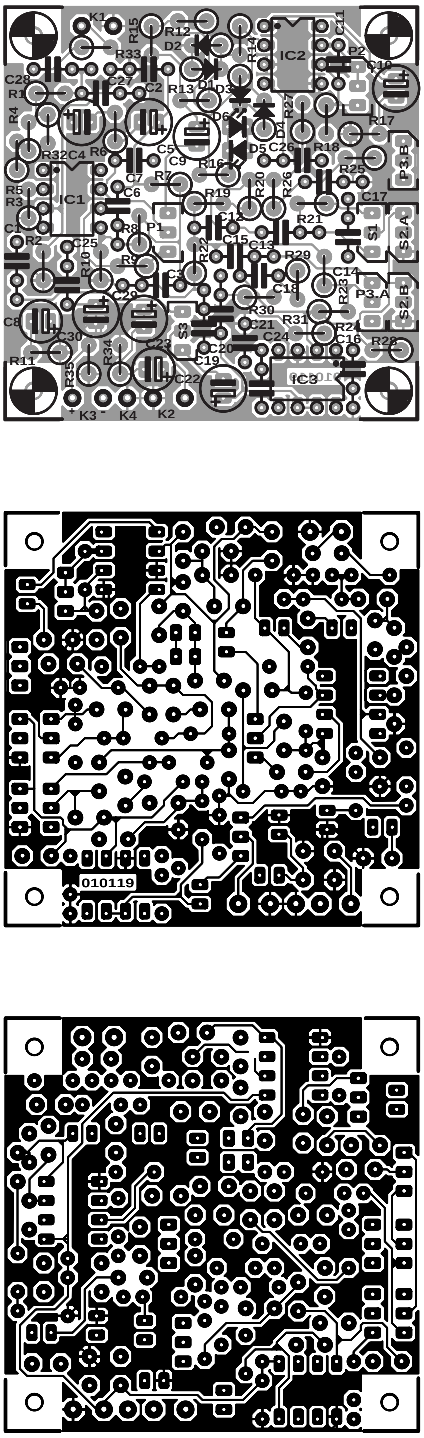
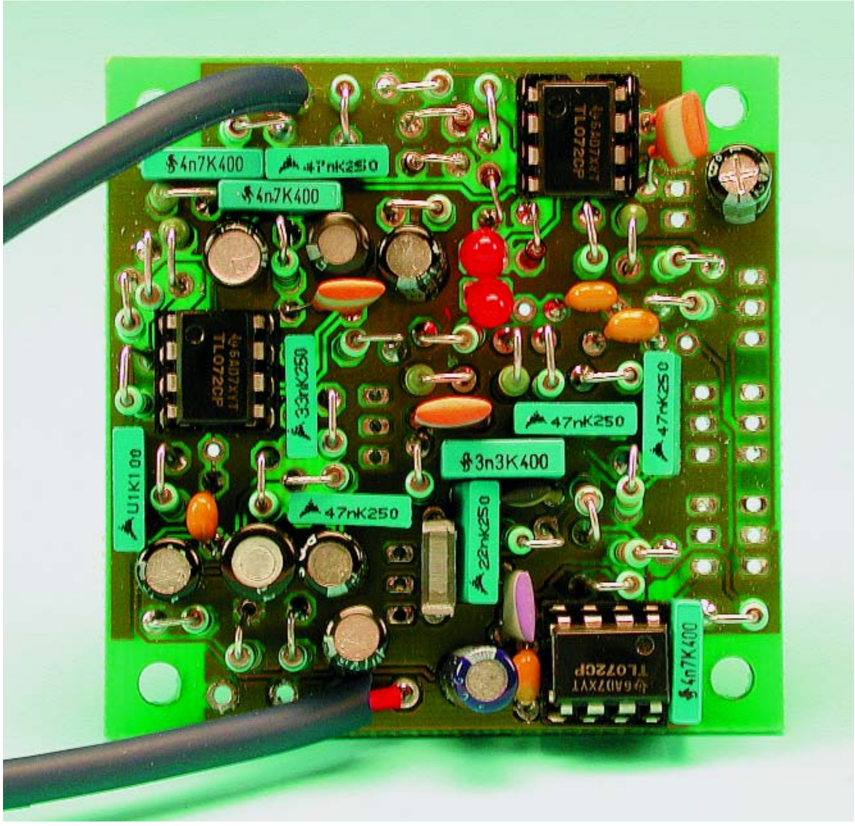


Figure 2. Layout and component mounting plan for the tiny printed circuit board (board available ready-made).



COMPONENTS LIST

Resistors:
R1 = 511kΩ
R2 = 680kΩ
R3 = 6kΩ8
R4 = 15kΩ
R5 = 1kΩ2
R6 = 1kΩ
R7,R8,R10 = 8kΩ2
R9,R29,R34,R35 = 2kΩ2
R11 = 1kΩ8
R12 = 470kΩ
R13 = 3kΩ3
R14 = 100Ω
R15,R26,R31 = 33kΩ
R16 = 220kΩ
R17,R21,R23 = 47kΩ
R18 = 91kΩ
R19,R20 = 43kΩ
R22 = 100kΩ
R24 = 22kΩ
R25,R33 = 68kΩ
R27 = 470Ω
R28 = 180kΩ
R30 = 10kΩ
R32 = 5kΩ1
P1,P2 = 100kΩ potentiometer, logarithmic law
P3= 50kΩ potentiometer, stereo, logarithmic law

Capacitors:
C1,C17,C24,C25,C26 = 100nF
C2,C3,C13,C14 = 47nF
C4,C5,C29,C30 = 10µF 16V radial
C6 = 33nF
C7,C11 = 470pF
C8 = 1µF 16V radial
C9 = 1µF 16V radial
C10 = 2µF2 16V radial
C12 = 560pF
C15 = 3nF3
C16,C27,C28 = 4nF7
C18 = 100pF
C19 = 39nF
C20 = 22nF
C21 = 220pF
C22 = 22µF 16V radial
C23,C29,C30 = 10µF 16V radial

Semiconductors:
D1-D4 = 1N4148
D5,D6 = LED, red
IC1,IC2,IC3 = TL072-CP*

Miscellaneous:
K1,K2 = jack socket, 6.35mm, chassis mount*
K3 = solder pin
S1 = rocker switch, 1 x c/o
S2 = rocker switch, 2 x c/o
S3 = pedal switch
Enclosure: Hammond type 1590B*
PCB, order code **010119-1** (see Readers Services pages)

PCB layout available from Free Downloads section at www.elektor-electronics.co.uk

The output of the tone control circuit is connected via a buffer-amplifier. The signal now passes through a further high-pass filter and buffer, before being taken to the output connector via footswitch S3.

The distortion circuit can be powered from an external regulated mains supply, connected via low-voltage jack K1. Alternatively, a 9 V battery can be used to power the circuit. For this option, the type TL072 op-amp should be avoided in favour of low-current quad op-amps such as the pin compatible rail-to-rail OP470.

Construction and Test

Given the small dimensions of the circuit board (**Figure 2**), the component density is very high. The majority of components are mounted vertically, and so it is particularly important to fit the smaller components first and the taller ones later. So, first fit the diodes, the LEDs, the IC sockets and capacitors (with the exception of the electrolytics), the wiring to the potentiometers and switches, and finally the resistors, electrolytics and solder pins for the signal inputs and outputs, power supply and ground (screen).

Figure 3 shows how the controls are connected. The circuit board should be fitted in a suitably-sized metal enclosure to screen the electronics from interference. For the same reason, the circuit ground (on K4) should be connected to the enclosure. This can be done with a solder tag to the base of the enclosure. For our prototype we used a Hammond enclosure type 1590B, which is very small and does not have space for a battery. To save space, instead of chassis-mounted jack sockets we used a short length of screened audio cable to connect the inputs and outputs to in-line jack sockets. Strain relief is essential for these cables.

If you would prefer to use chassis-mounted jack sockets, a larger enclosure will be required. Then no solder tag ground connection to the enclosure will be required, since jack sockets which are not isolated from the enclosure will do the job instead.

As well as screening the electronics, the metal enclosure has another advantage: it is very robust and so can stand up to rough treatment on stage.

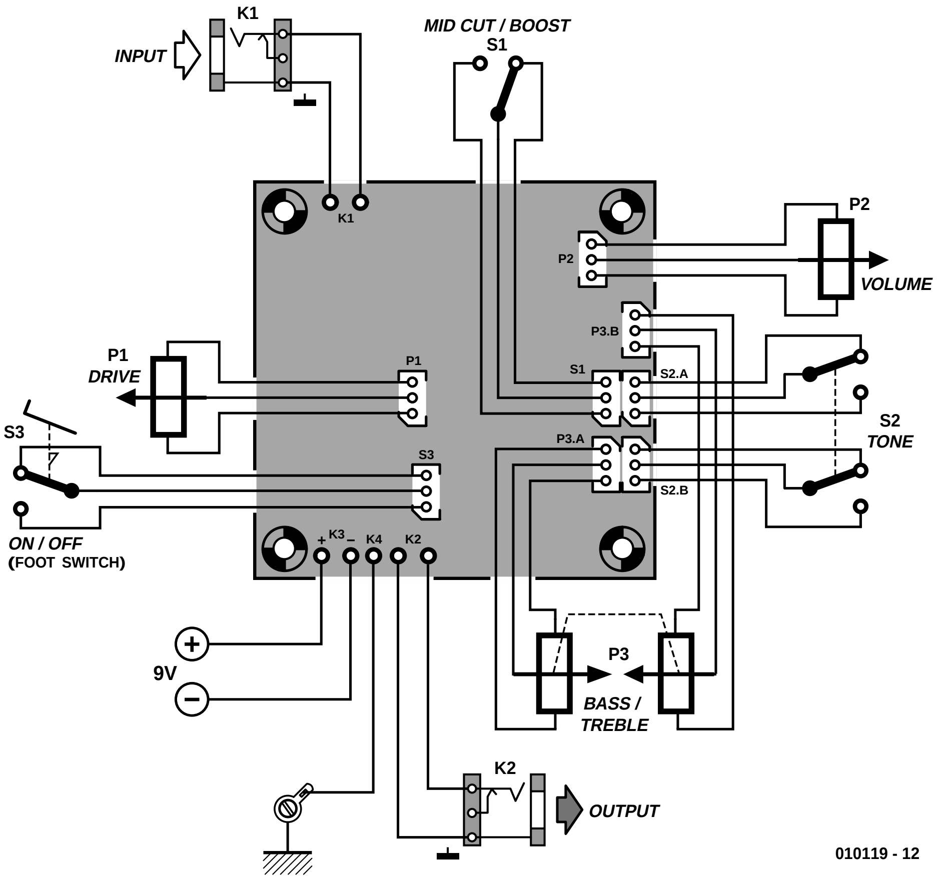


Figure 3. The connections at a glance.

To test the unit, connect up the Tube Box and set volume control potentiometer P2 to its minimum position. Strike a chord on the guitar: if nothing can be heard, press the footswitch to bypass the unit. Press the footswitch again, and the distortion circuit is switched in and P2 can be adjusted to set the desired volume. Finally, set the degree of distortion using P1 and adjust the tone as required using S1, S2 and P3.

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